51. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCEEDINGS

11-15 September 2006

FACULTY OF ELECTRICAL ENGINEERING AND INFORMATION SCIENCE

INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING - DEVICES AND SYSTEMS, MATERIALS AND TECHNOLOGIES FOR THE FUTURE

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=12391

TECHNISCHE UNIVERSITÄT
ILMENAU

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff

Redaktion: Referat Marketing und Studentische Angelegenheiten
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Susanne Jakob
Dipl.-Ing. Helge Drumm

Redaktionsschluss: 07. Juli 2006

Technische Realisierung (CD-Rom-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Marco Albrecht
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag: isle
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilrnenau

ISBN (Druckausgabe): 3-938843-15-2
ISBN (CD-Rom-Ausgabe): 3-938843-16-0

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=12391

51st Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
September 11 – 15, 2006

S. Hetzel, W. Schufft,

Assessment of investment strategies in medium-voltage cable grids

Summary

Since the opening of the German energy market and against the background of decreasing investments, people have been searching for solutions to operate existing, historically grown medium-voltage cable grids with the available financial means in the most efficient way.

So far, the emphasis was primarily focussed on estimations of the grid reliability as well as assessments regarding the risk of fault. The purpose of this was to optimise maintenance strategies and to reduce costs.

Within this paper a model will be presented, which supports the evaluation of investment options in medium-voltage cable grids. Thereby a database adapted to the existing demands is a precondition. Considering several aspects, these data were entered into a self-developed simulation program.

It was shown by means of an example: based on existing data of a power utility, an appropriate simulation program can help to justify or to reject investment intentions or strategies.

Initial Situation

Attributable to the liberalisation of the energy markets, power utilities reduced their investments in power transmission and distribution networks from € 2,449 M in 1999 to € 1,650 M in 2003 [1]. This means a reduction to 67%.

Although, since 2003 the investments increase, the medium- and long-term effects of these already realised investment decisions and strategies on the reliability and quality of the power supply are of particular interest [2]. This applies especially to the German regulatory authority (Bundesnetzagentur).

The availability of electricity is one of the key criteria for the assessment of the supply quality. It is mainly determined by the medium-voltage power grid [3], especially by the condition of the existing cable installations. For that reason, we will deal in the following especially with the effects of investment strategies in medium-voltage cable grids. The presented assessment model shall address technical as well as economic factors.

As a medium-term result of analysis an optimum solution for the question of economic sustainable placed investments is expected, which matches the interest of all power utilities as well as the interests of the electricity customers represented by the Bundesnetzagentur. So far, the aim is to identify, to prioritise and to summarise appropriate sub-aspects in a common optimised target function.

Course of Action

As a result of the considered real systems, a high degree of complexity and heterogeneity is anticipated. This can be attributed to the historical growth of the power grids and the former aspiration of developing structures with highest possible reliability. Figure 1 shows a course of action to be used as a structured approach [4].

The initial point is hereby the analysis of the current cable resources. As other relevant resources of the medium-voltage distribution grids cable joints and cable terminations were identified. For simplification , we break down the grid and focus solely on medium-voltage cables. Furthermore we assume that it is impossible to maintain the considered cables. With this in mind we proceed with the fact, that only replacement and new investments are relevant.

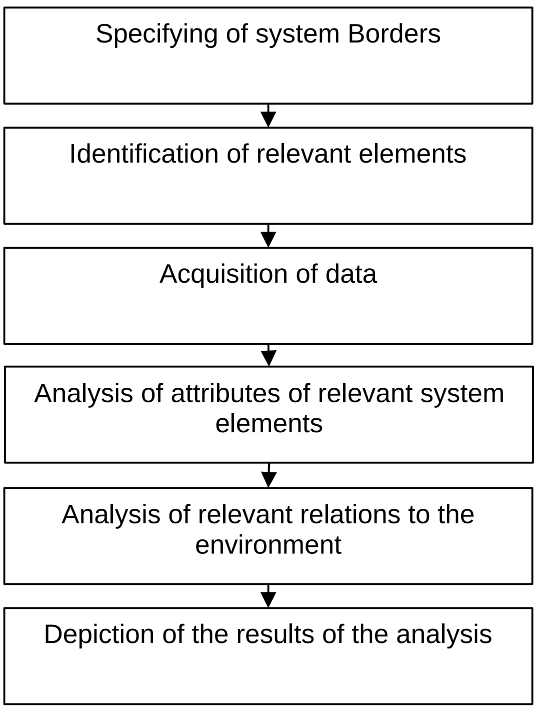

Fig. 1 – Genaral procedure

The question on how to use the available investment appropriations in the most efficient manner has to consider many different aspects.

Some of them are

- operators experience
- type, age and structure of the used equipment
- the internal fault statistics of the utility
- procedures of condition assessment [5] and the emerging results

Based on this knowledge in combination with additional facts and data it is possible to create a solution support system for evaluating the profitability of investments. A conceivable system is shown in Figure 2.

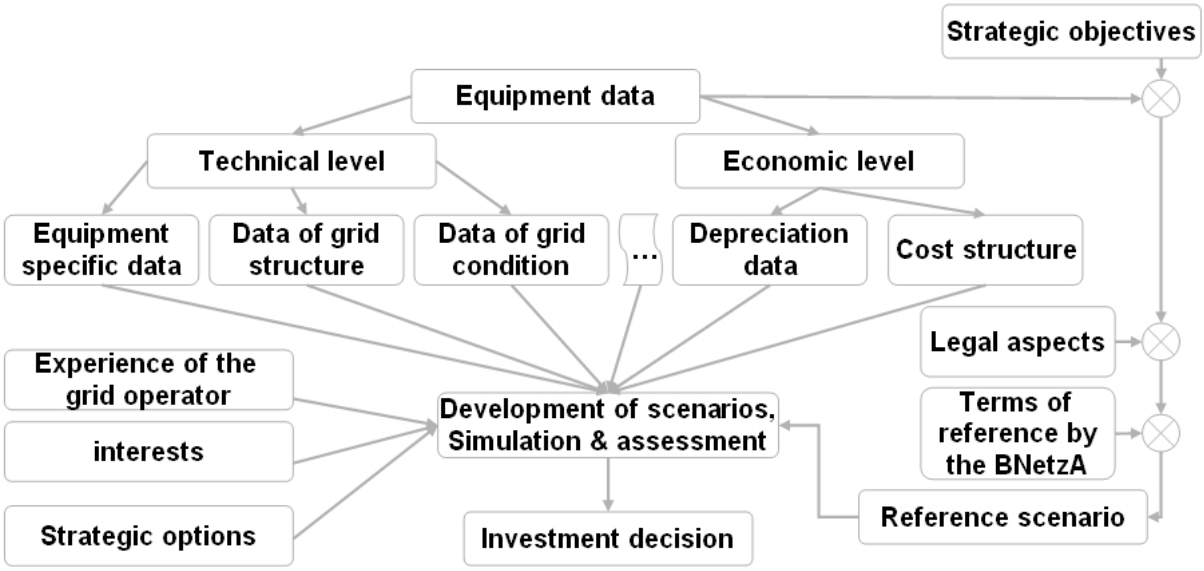

Fig. 2 – Proceeding

The key challenge is the identification of the relevant factors. Additional it is necessary to find opportunities for an objective assessment of those. A possible approach is shown in Figure 3.

Since it must be assumed that the relevant data have to be gained from several software tools, which may have different types of data format and cause incompatibilities to each other. With this in mind, it is necessary to develop a universally applicable identification system. This enables a more sophisticated assignment to different utilities and to various regional parts of one utility grid. Furthermore, this allows a classification on the basis of structural characteristics. Afterwards, an analysis of the current cable resources in terms of age structure and existing cable types is necessary. As a result, it is expected to gain a profound overview over the existing cable grid.

In contrast to high-voltage equipment, gaps in documentation can be assumed. Moreover, due to the various dedicated software tools the different data stocks often show inconsistencies.

By solving these problems, a proved database of the existing equipment can be transformed into an analysing system.

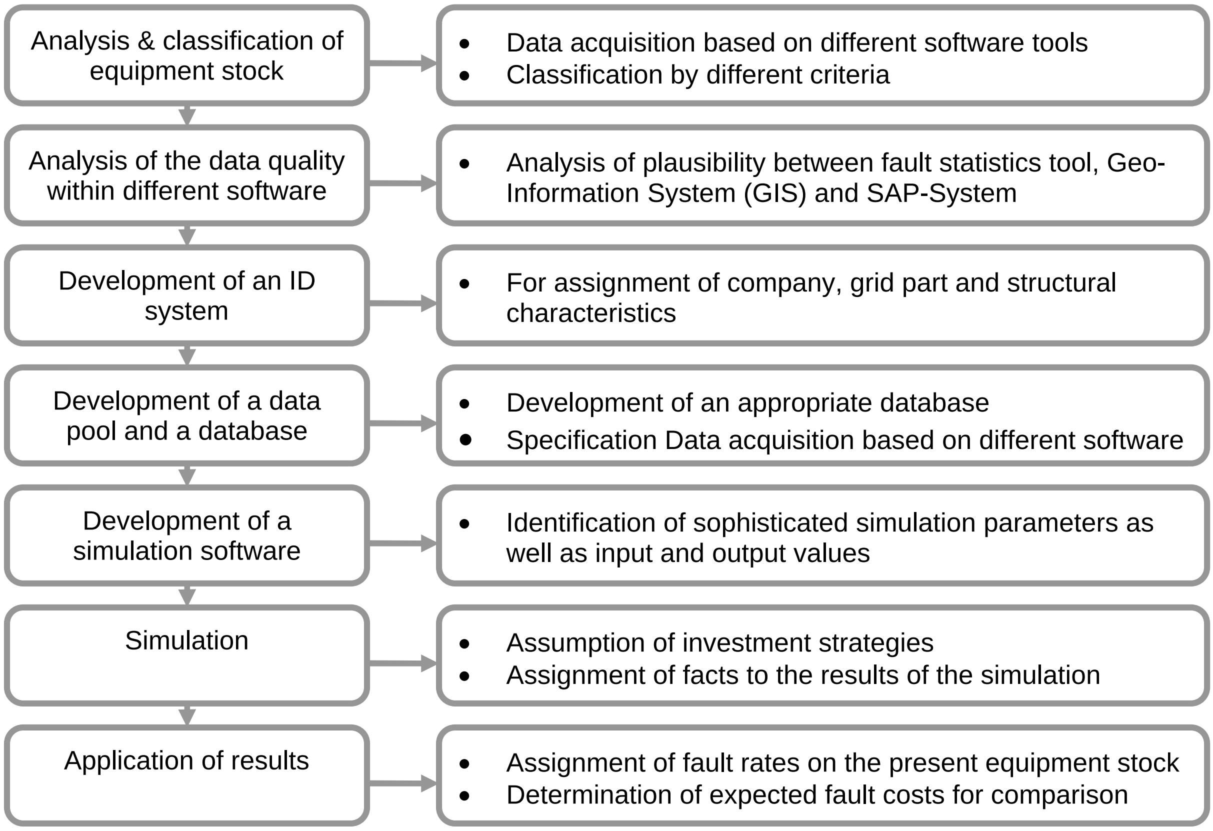

Fig. 3 – Course of action

A conflation of the relevant parameters from this database, as shown in Fig. 3, yields in further consideration of external conditions a basis for the development and simulation of alternative investment strategies. Special attention needs to be placed on the experience of the operator with the applied equipment and the fault statistics, which is the base for the fault assessment of the simulated structures. Resulting from grid segments which do not meet the requirements of oil-paper-cable, for example a segment with oil-paper and XLPE cable in one section, special care of conspicuous oil-paper-cable segments is necessary [6].It can be assumed, that in these sections no oil-flow is possible. This can be an indicator for dry oil-paper-cable parts, which tend to a higher fault rate in comparison to maintained oil-paper-cable parts with a very low fault rate. While ensured statements are still missed, one should take the worst case as a starting point, i.e. interrupted oil-paper-cables. However, this may lead to higher costs, which refer to a premature replacement of oil-paper cable segments. To solve this problem, a more sophisticated view on the structure of the oil-paper-cables is necessary. Different maintenance strategies are one of the results of this differentiation. This requires a further distinction of all cable resources on the basis of the individual cable stretches and increases the degree of complexity of the consideration in general.

In summary, these considerations conclude that due to the historical growth of the grid and the usual procedure in the case of faults the age of a section is not homogeneous. This has to be considered in corresponding simulations.

The objective of identifying weak points requires, as previously mentioned, precise fault statistics data of the utility. To obtain convincing results, it is necessary to assign faulty parts directly to the respective segment of the grid. This allows for example the assignment of a fault to a mixed or a pure oil-paper-cable segment. Another key factor is the identification of trends from the condition assessment. At this, the recognition and identification of fault patterns plays an important role, which is, however, not part of this article. For a comprehensive study of the existing distribution grid, the economic parameters of the installed equipment are also interesting. A database which meets these requirements forms the basis for comprehensive analyses of the existing equipment.

Possible Solution

Initial point was the examination of different medium-voltage cable grids of regional power utilities with focus on the preceding considerations. A first key issue was to ensure the required minimum data quality. At this, the part of the utility fault statistics and the analysis of the equipment stock were of special interest and the quality of data was the main point to ensure. Based on former inversment values of the utilities, it was possible to simulate initial reference scenarios. Thus it was proven that the actual investment strategy won't deliver optimum results concerning the forecasted faults within the considered period until 2016 and beyond. The results are shown in Fig. 6.

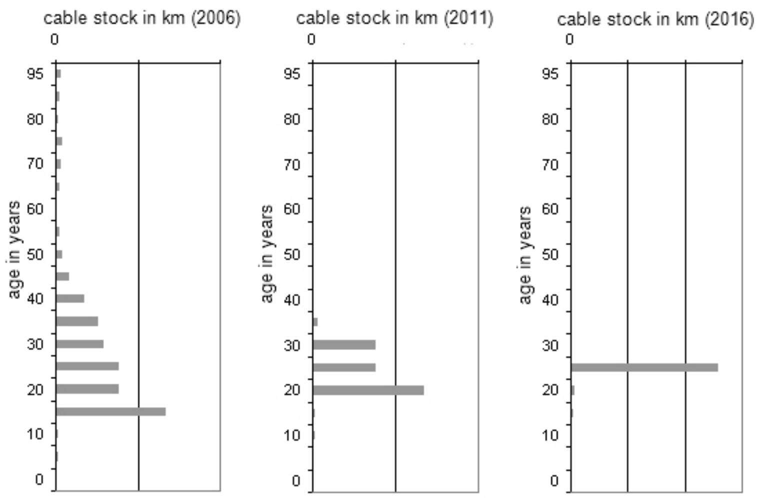

Fig. 4 – Expected age structure (reference scenario)

It has to be mentioned that for this initial simulation, a historically derived, relatively high investment quota was taken as a basis. This reflects the high investment amounts allocated in the field of cable grids during the 1990s in Eastern Germany.
It has to be remarked that within this first scenario, the priority of cable exchange was set primarily on oil-paper cables.
With respect to the known high reliability of well maintained oil-paper-cable sections, such an approach does not represent an economic optimum.
This is illustrated by a simulation of the same equipment stock with a volume of investments reduced by 50%. In the considered period lower fault rates arose while the annual replacement rate declined to below 1.75%. According to this, the amount of older cable sections in the grid increases, as shown in Fig. 5.

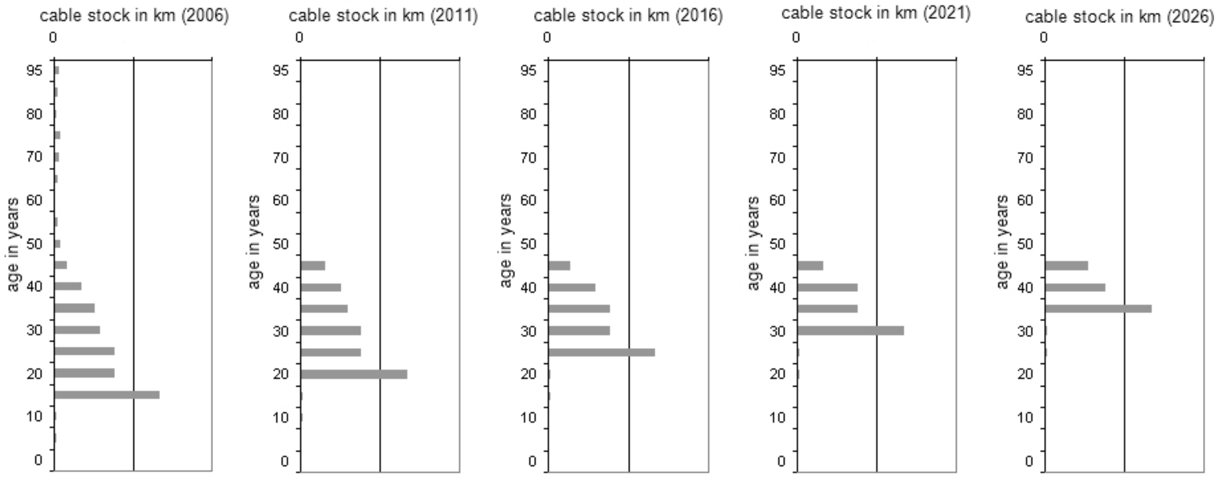

Fig. 5 – Simulated age structure

The decrease of the forecasted faults, see Fig. 6, was reached by a selection and a reallocation of the available investment resources to the existing equipment. In both cases, the conducted estimation of expected faults was based on the analysis of the fault statistics of the

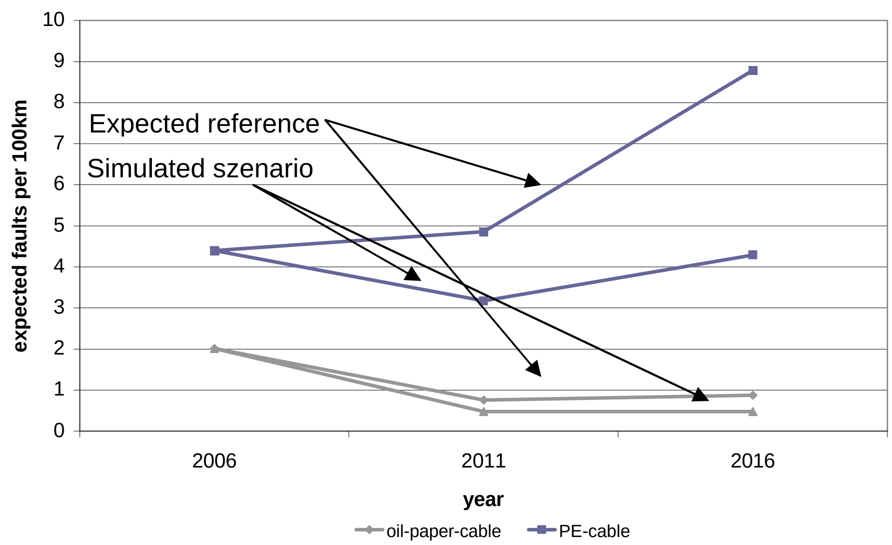

Fig. 6 – Expected faults

utility as well as the fault statistics of the German association of grid operators VDN [7]. The results of this analysis were applied to the simulation results.

The premise of this initial analysis was the assumption of continuous investments in the power distribution grid spread equally over the replaceable equipment. Despite a halved volume of investment, the surprising result was a fault reduction by about 50% (Fig. 5).

This result refers to all explored cable grids including the grids of several utilities. Costs can be assigned to the fault predictions obtained by simulation and assessment. The utility knows about the average directly assignable costs which arise from a fault. This enables the utility to determine the costs emerging due to realised or postponed investments.

This applies likewise to the estimation of potential future obligations regarding quality regulation the utilities have to reckon with. [8]

Conclusion

To sum up, one can say that a system for investment assessment in medium-voltage cable grids has to be able to model and simulate highly complex relations. These relations are the result of historically grown structures and versatile relationships to the economic and regulatory environment.

In a first step, a system for simulating the ageing of the grid on the basis of simple relations in medium-voltage power grids was developed. It is possible to show the expected age structure of the grid on a cable segment basis. This allows an assessment of expected faults by using historical fault rates. By applying present fault costs to the results of the simulation it is possible to determine future fault costs. So the simulated fault and cost scenarios enable further assessments and the development of investment strategies.

The benefit of this approach is the selective identification of weak segments and thus of direct investment needs attributable to the consideration on cable segment level.

Moreover, these considerations are transferable to the future. This enables an estimation of the advantages of investments effected today.

With the simulation facility a first software tool has been realised which allows such considerations.

Especially the use of historical data for fault probability is a critical factor. The same applies to the differently assumed attributes of mixed and pure oil-paper-cable sections.

This shows a significant challenge for research and action in these cases and also in the framework of assessments concerning the investment profitability in the medium-voltage cable grid.

References:

[1] Bantle, C, Mehr Investitionen in Energienetze, in ew. 4-2006 Jg. 105 P. 18ff

[2] Nitzschke, Dr. D., Oberländer, F. u.a. Modellierung von Einflussgrößen auf Netzkosten und Versorgungszuverlässigkeit mit dem Modellnetzvefahren, in ew. 6-2006 Jg. 105 P. 24ff

[3] VDEW, Daten und Fakten, Stromnetze in Deutschland 2004, Berlin, 2004 P. 21

[4] Krallmann, Frank, Gornau, Systemanalyse im Unternehmen, 1999, P. 45 ff

[5] Schufft, W., Schreiter, F., Jilek, U.: Kombination von diagnostischen Messungen und Stehspannungsprüfungen zur Ermittlung der Isolationsreserven von verlegten Mittelspannungskabeln. HIGHVOLT-Kolloquium '03, 22.-23.05.03 Dresden

[6] Gulski, E., Quak, B., Smit, J.J., Groot, E.R.S.: Asset Management Decision Support for HV Infrastructure Lifetime Management, XIVth International Symposium on High Voltage Engineering, Beijing, 2005

[7] VDN-Verfügbarkeitsstatistik, Berlin, 2005

[8] Bundesnetzagentur, Entwurf des Berichtes der Bundesnetzagentur nach § 112a EnWG zur Einführung der Anreizregulierung nach §21a EnWG, 02.05.2006, P. 211ff

Authors:

Steffen Hetzel
Wolfgang Schufft
Technische Universität Chemnitz
Reichenhainer Str. 70
09107 Chemnitz
Phohe: 0371-531-3342
Fax: 0371-531-3376
steffen.hetzel@etit.tu-chemnitz.de
wolfgang.schufft@etut.tu-chemnitz.de